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# Adrenocortical Attunement, Reactivity, and Potential Genetic Correlates Among Parent-Daughter Dyads from Low-Income Families

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## Abstract

Examining the multitude of influences on the development of adolescent stress responses, especially among low-income families, is a critical and understudied topic in the field. The current study examined cortisol attunement between adolescent girls and parents (mostly mothers) from predominantly low-income, single parent, ethnic minority families before and after an in-laboratory disagreement discussion task. The sample consisted of 118 adolescents ($M_{age}$ = 13.79 years, 76.3% ethnic minorities, 23.7% European Americans) and primary caregivers ($M_{age}$ = 40.62 years; *Mdn* yearly income = $24,000; 43.2% single parents; 50% living below poverty line). We investigated oxytocin receptor (OXTR rs53576) gene variations as a potential contributor to attunement within the dyad. Results showed that parents and adolescents showed stress system attunement across the disagreement task, but that parent and adolescent oxytocin receptor genotype did not impact attunement. Future studies should detail biological factors that contribute to the calibration of stress response systems of adolescents across a variety of samples, particularly those experiencing a combination of stressors.

### Keywords

adrenocortical attunement; *OXTR*; stress response; disagreement discussion; adolescent development

The plasticity of the stress response is the mechanism by which the broad effects of environmental factors are proposed to play a role in the downstream development of behaviors (e.g., social withdrawal; Flinn, Nepomnaschy, Muehlenbein, & Ponzi, 2011), competencies (e.g., emotion regulation; Pellegrini, 1998), milestones (e.g., timing of maturation; Belsky, Houts, & Fearon, 2010), and psychopathology (e.g., anxiety, depression; Laurent & Powers, 2007). The stress response systems have been proposed to calibrate physiology to adapt to myriad contextual factors occurring primarily within the family,

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including environmental cues or conditions (Del Giudice, Ellis, & Shirtcliff, 2011). These environmental cues become especially important during adolescence, a developmental "switch point" in human life histories (Del Giudice, Angeleri, & Manera, 2009). The current study examined the contribution of genetic and environmental factors to stress responses (via salivary cortisol) among adolescents from predominantly ethnic minority, single parent, and low-income families. Specifically, we investigated whether parents and their daughters showed adrenocortical coordination during a disagreement discussion task and whether the level of stress system coordination varied by parent and adolescent genotype.

## Developmental Transformations during Adolescence

Adolescence is characterized by a number of critical developmental changes and transformations within the youth and within the adolescent's interpersonal relationships (Steinberg & Morris, 2001). In addition to advances in cognitive development (e.g., abstract thinking; Steinberg, 2011), social cognition (e.g., perspective taking; Selman, 1980), and emotion understanding and regulation (Morris, Silk, Steinberg, Myers, & Robinson, 2007), adolescents experience transformations in their physical appearance (Susman & Rogol, 2013) and brain maturation (Steinberg et al., 2009). Relationships with parents become more horizontal and less vertical as the relationship becomes more peer-like during adolescence (Steinberg & Morris, 2001). As such, any potential patterns of adrenocortical coordination between parent and adolescent must be considered in the context of these developmental changes.

Investigating the roles that parents and peers play in emotion socialization may be especially salient among adolescent girls from predominately low-income, single parent, ethnic minority families. For example, girls from low-income families are at increased risk for emotion-related difficulties (e.g., internalizing symptoms), in part due to the gap between physical development and cognitive and brain maturation (Steinberg et al., 2006), which tends to be larger due to the early onset of puberty among low-income girls (Ellis, McFadyen-Ketchum, Dodge, Pettit, & Bates, 1999). In addition, compared to the peer relationships of boys, evidence in the literature has demonstrated that girls' friendships tend to be characterized by higher levels of self-disclosure, open communication, affection, and emotional support (Bell, 1989; Criss, Smith, Morris, Liu, & Hubbard, 2017; Rose, 2002). Moreover, girls' relationships with their mothers tend to be focused more on emotions and display higher levels of openness communication and emotional support (Bardack & Obradović, 2017; Criss et al., 2016). In addition, compared to boys, girls tend to have closer, warmer, and more supportive relationships with their parents marked by higher levels of affective synchrony (Bardack & Obradović, 2017; Criss et al., 2016; Larson & Richards, 1994). Thus, studying adrenocortical attunement among mother-daughter dyads in predominantly low-income, single parent, and ethnic minority families would be quite informative.

## Stress Responses and Adrenocortical Attunement

Social challenges, such as those involved in managing family and other close relationships, are reliably linked to hypothalamic-pituitary-adrenal (HPA) axis activity and its primary

glucocorticoid product, cortisol (Del Giudice et al., 2011). However, whereas traditionally studies of social challenges have examined the cortisol reactivity of a single person within the social context, a more recent innovative approach to studying the biopsychosocial dynamics within family relationships is the study of attunement (i.e., attunement of adrenocortical function) between family members (Hibel, Granger, Blair, & Finegood, 2015). This method moves beyond studying an individual's biological responses to social stressors and allows for the examination of how individuals within relationships influence each other both behaviorally (i.e., interactional attunement) and biologically. This approach may have evolutionary implications and may be the key to understanding how family dynamics impact important outcomes and may be especially critical during adolescence given the social, emotional, and physiological changes during this developmental period.

The study of biological attunement, especially in terms of cortisol, has been primarily limited to marital or romantic dyads (Papp, Pendry, Simon, & Adam, 2013) and mother-infant relationships (Hibel et al., 2015; Middlemiss, Granger, Goldberg, & Nathans, 2012), though there have been some studies conducted with mother-adolescent dyads. These investigations have shown similar patterns, with cortisol attunement being more robust among dyads who spend more time together compared to others during disagreements and challenges (Papp, Pendry, & Adam, 2009). For example, shared time together and parental monitoring moderated mother-adolescent cortisol attunement. Further, they found that physiological attunement is responsive to situational psychosocial factors, in that temporarily elevated negative affect was related to cortisol attunement within the family.

In the context of the current study, we utilize the term "physiological attunement" to characterize the relationship between the adrenocortical activity that exists with the parent-youth dyad rather than "synchrony," which implies an exact match in physiological states over the same time. Although previous studies have utilized the terms interchangeably and/or as synonymous, we differentiate the two terms, such that "attunement" implies that although the exact patterns may not match, members of a dyad show a complementary pattern and one consistent with individuals within a dyad regulating each other's physiological states, particularly during times of challenge or threat (Beckes & Coan, 2011; Ha & Granger, 2016; Timmons et al., 2015).

Few studies, however, address the reciprocal physiological links between the parent and child during this developmental transition, instead most have focused on early and middle childhood. A recent study with children in middle childhood showed that maternal characteristics and child age moderated mother-child cortisol attunement (Borelli et al., 2019). Furthermore, the limited research on parent-adolescent dyads affords minimal insights into the role that physiological cascades play. Preliminary evidence has demonstrated links between parent-child interactions and various physiological indicators of well-being. For example, Cui, Morris, Harrist, Larzelere, and Criss (2015) reported that within-dyad positive affect (observed during a disagreement task) was positively related to respiratory sinus arrhythmia (RSA), another index of stress system activity, among adolescent girls. Furthermore, evidence in the extant literature has demonstrated that cortisol attunement is linked to positive and negative aspects of the parent-child relationship (Hibel et al., 2015; Ruttle, Serbin, Stack, Schwartzman, & Shirtcliff, 2011). This suggests that

attunement at many developmental points may provide an index of relationship functioning or sensitivity to behavioral cues within the parent-child dyad (Middlemiss et al., 2012). As Saxbe and Repetti (2010) note, adrenocortical attunement cannot accurately be labeled as "bad" or "good" relationship phenomenon, but rather an index of physiological interdependence and how the dyad navigates threats and challenges together. Moreover, it is possible that adolescents who experience multiple stressors (e.g., low-income, single parent families) may rely more readily on biosocial information gleaned from interactions with parents. As noted above, because adolescent girls in these contexts are at risk for a number of negative outcomes, it is imperative that we understand the process through which they may utilize their relationship with their parent to assist them in navigating challenges.

## Genetic Contributions to HPA Axis Activation

Another understudied contributing factor to parent-child dynamics and associated emotion regulation is an individual's genotype (Bakermans-Kranenburg & van IJzendoorn, 2008). To understand factors related to biorhythms within relationships, recent attention has turned toward studying individual variability in genes associated with social cognition and behavior. The oxytocin system (OXT) has been established as a moderator of social behavior across a variety of mammalian species (Insel, 2010). Specifically, oxytocin (OT) is a hormone found on chromosome 3p25, and one SNP in the third intron of OXTR, rs53576 (G/A) that is arising as an important factor in human social behavior. That is, OT has been repeatedly linked to prosocial temperamental phenotype, optimism, mastery, self-esteem, affiliative behavior, hypothalamic structure and function (Tost et al., 2010). Moreover, it has been identified as one of the key neurobiological mechanisms linking prosocial or affiliative behavior to stress reduction (Taylor et al., 2000), and may decrease behavioral and physiological responses to environmental stressors (MacKinnon & Luecken, 2008). This intricate relationship between the oxytocin and stress response systems reflects clear adaptations within the human nervous system for sociality (Adolphs, 2009).

The oxytocin system and the HPA axis are intricately intertwined, with the most research showing that oxytocin exerts a buffering effect on HPA axis activity, particularly due to psychosocial conflict or challenge. For example, prairie voles recovering from stressful event with a partner showed increased oxytocin and reduced cortisol compared with those recovering from the event alone (Smith & Wang, 2014). Oxytocin is associated with women's reduced cortisol response during dyadic conflict with a romantic partner (Flanagan, et al., 2018). Importantly for this investigation, exogenous oxytocin administration was associated with reduced cortisol responses in individuals with lower emotion regulation abilities (Quirin, Kuhl, & Dushing, 2011). Further, investigations of triadic family interactions (mother, father, and infant) have showed that oxytocin predicted maternal and paternal proximity and physical touch with their infant, and that triadic behavioral synchrony and oxytocin were related to lower cortisol levels in mothers (Gordan, Zagoory-Sharon, Leckman, & Feldman, 2010).

It should be noted that many of these links may be moderated by context, particularly the interpersonal dynamics within the psychosocial context (Michalska et al., 2014). For example, the GG allele (but not the AA allele) has been associated with reduced cortisol

reactivity to a stressful task after receiving social support prior to the stressor (Chen et al., 2011). Importantly for the current study, OXTR has been shown to influence parent-infant interactional or behavioral attunement (i.e., parent-infant gaze; Feldman et al., 2012). Maternal oxytocin receptor polymorphisms also have been shown to impact cortisol responsiveness during breastfeeding in both mothers and infants, suggesting that genetic variation may, in part, underlie individual differences in the development of the stress response (Krol, Monakhov, Lai, Ebstein, Heinrichs, & Grossman, 2018). Moreover, previous research has established that OXTR polymorphisms are important in social behaviors, and that dynamics in important relationships are underscored by physiological attunement. To the best of our knowledge, there have been no published studies investigating how parent and adolescent OXTR genotype influence physiological attunement during a disagreement discussion task.

## Assessing Parent-Adolescent Interactions

Disagreement discussion tasks in laboratory settings are commonly utilized to measure stress responses within marital couples. Stress responses to these tasks have been shown to predict important relationship outcomes and are influenced by childhood adversity (Winer, Powers, Pietromonaco & Schreck, 2018). In addition, this methodology has been used with parents and adolescents and shows that adolescent cortisol response during these interactions predict both internalizing and externalizing behaviors (Steeger, Cook, & Connell, 2017). Furthermore, interactions characterized by adolescent and maternal negative affect were associated with enhanced physiological synchrony (Papp et al., 2009). Given the critical role that parents play in the development of emotion regulation skills (Morris, Criss, Silk, & Houltberg, 2017), it is important that we understand how the stress response may be co-regulated during these discussions, particularly for adolescents and parents experiencing multiple, simultaneous stressors as is typical for low-income families. Adrenocortical attunement may be one mechanism by which emotion regulation skills are transferred from parent to youth.

## Current Study

In sum, the literature has indicated that parents and children show stress response system coordination, and this is especially true in times of challenge. The oxytocin (OT) system plays a role in regulating social behavior, and variations in polymorphisms of OT receptor genes predict some affiliative behavior. Despite the knowledge the literature has provided, there are several gaps in the literature that must be acknowledged. First, whether and how stress response coordination occurs during times of challenge in parent-adolescent dyads from economically and ethnically diverse backgrounds is less clear. Moreover, there is a relative dearth of research explaining whether OT receptor genes play a role in stress response system coordination, especially among adolescent girls from predominantly ethnic minority and low-income families.

To address these gaps, the current study had two major research goals with the following hypotheses. For the ***first research goal***, we investigated whether adrenocortical attunement occurs within a parent-adolescent disagreement discussion task in predominantly low-

income, single parent, and ethnic minority families. This research goal was evaluated using four analytic methods as discussed in the data analysis section. For the ***second research goal***, we analyzed whether parent and adolescent genetic polymorphisms contributed to adrenocortical attunement within the parent-adolescent disagreement discussion task. This second research goal expands on the first research goal to investigate whether adrenocortical attunement investigated in the first research goal is moderated by genotype. Specifically, we expected that adrenocortical attunement would differ by parent genotype such that attunement would be stronger among caregivers and adolescents with GG alleles.

## Method

### Participants

The initial study consisted of 171 dyads of adolescent girls and one of their parents (81.2% biological mother, 4.7% biological father, 3.5% female grandparent, 2.9% female adoptive/foster parent, 2.9% Stepmother, 1.2% Stepfather, 1.8% other female caregiver). Funding for the cortisol component of data collection was not secured until after data collection for the first 43 dyads; therefore, these participants were not included in the current study. We compared families with and without cortisol data and found no statistically significant differences with respect to adolescent ethnicity, adolescent age, parent age, parent relationship to adolescent, and living below the poverty line. Male caregivers (biological fathers and stepfathers) were also excluded from the analysis due to overall low sample size (only 8 fathers and 3 stepfathers) and evidence suggesting that andrenocortical attunement may function differently in father-youth interactions compared with mother-youth interactions (Saxbe et al., 2014). While we could have controlled for parent gender, we were concerned that including such a small sample of fathers would induce bias. This resulted in an effective sample size of $N = 118$ dyads. The adolescent girls ranged in age from 12.00 – 16.83 ($M = 13.79$) and were predominately African American (see Table 1). The primary caregivers ranged in age from 27 – 67 years old ($M = 40.62$) and reported racial compositions that varied from the adolescent girls (50.8% African American, 39.0% Caucasian, 0.8% Hispanic/Latino, 8.5% Native American, 0.8% other). The sample was predominantly comprised of low-income families (*Mdn* yearly income = $24,000), with 43.2% headed by single parents and a mean of 4.47 people living in each home ($SD = 1.54$). In addition, 50% families were living below the poverty line.

### Procedure

Participants were recruited from a Midwest city and surrounding areas through fliers distributed at area schools, public facilities, and local Boys and Girls Clubs. In addition, snowball sampling was used by asking that participating families distribute fliers to friends. The families participated in the project for four weeks. Data from the Week 1 laboratory assessment was used in the current study. Lab assessments were scheduled at different times on Saturdays (i.e., 9 AM, 12 PM, and 3 PM) depending on the availability of the family. After the 5–10-min consent process, the primary caregiver and adolescent completed a series of questionnaires separately. Typically, the surveys took 30–45 minutes to complete. The parent and adolescent next participated in a 6-min disagreement discussion that was based a procedure developed by Melby and colleagues (1998). Specifically, the parent and

adolescent dyad was given cards containing the five most frequent disagreements that they reported on the Conflict Frequency Questionnaire (35 items, e.g., curfew, choice of friends; Melby et al., 1998). Each stimulus card identified the disagreement topic (e.g., "What is the conflict that we have about curfew?") and three questions about the conflict: (1) "Who is usually involved?" (2) "What usually happens?" and (3) "What can we do to resolve the problem?" The parents and adolescents were instructed to discuss as many disagreement topics as they wanted, up to five, during the 6-minute task. Saliva baseline sample was taken from the mother and adolescent 15 minutes prior to the task (Time 1; pre-task). After the Time 1 collection, the mother and adolescent finished any remaining questionnaires before starting the disagreement task. After completing the interaction task, the mother and adolescent took a 15-min break at which point the Time 2 (post-task) saliva collection was taken. Thus, there was approximately 36 minutes between Time 1 and Time 2 collections. Saliva was immediately frozen at −20°C until assayed for cortisol and analyzed for oxytocin receptor (OXTR) polymorphism, rs53576. These laboratory assessments typically lasted approximately 2½ hours. Participation in this study was a subset of a larger set of assessments, and each family received $225 ($175 for the adolescent and $50 for the parent) compensation for their participation in the entire set of studies. These procedures were approved by the university's Institutional Review Board (IRB).

## Measures: Salivary Cortisol

Following the recommendations of Granger et al. (2012), two whole, unstimulated, saliva samples were donated via passive drool immediately before and after the parent-adolescent disagreement discussion task and stored at −20°C. Samples were subsequently assayed for cortisol using commercially available reagents without modification to the manufacturer's suggested protocols (Salimetrics LLC, Carlsbad, CA). Test volume was 25 μL (assayed in duplicate), assay range of sensitivity was 0.007 to 3.0 μg/dL, and inter- and intra-assay coefficients of variation were below 10%. To correct a strong positive skew, cortisol values were log transformed (natural log) before statistical analysis.

## Measures: Genotyping

Saliva samples were taken from participants via passive drool. A Salimetrics modified PureLink Genomic DNA extraction method was used to isolate DNA from passive drool following Nemoda et al. (2011). Samples were aliquoted and stored at −20°C. Taqman® SNP Genotyping Assays (Applied Biosystems/Life Tech) were employed to amplify and detect the two alleles (A/G) for the rs53576 SNP of the oxytocin receptor gene (OXTR). Only one youth and one parent (not of the same dyad) were homozygous for the A allele. Therefore, we chose to compare individuals carrying at least one copy of the A allele (AA/AG) with GG individuals, as previously reported (Norman et al., 2011; Rodrigues, Saslow, Garcia, John, & Keltner, 2009). Those homozygous for the A allele were combined into one group with those that were heterozygous (AG), forming a group of A allele carriers (parent $n = 69$; adolescent $n = 65$) and compared with those homozygous for the G allele (GG; parent $n = 87$; adolescent $n = 95$). There were 15 parents and 11 teens for whom sufficient DNA could not be extracted from saliva. These were excluded from the analyses.

### Data Analyses

To address the first research goal, we investigated adrenocortical attunement within caregiver-adolescent disagreement discussion task among the sample of predominately low-income adolescent girls and their female caregivers (mostly biological mothers) of ethnic minority families using four analytic approaches. In the *first analytic approach*, following Middlemiss et al (2012), we investigated the correlations between the (natural log corrected) cortisol levels of caregivers and adolescents at Time 1 and Time 2. A strong correlation between caregiver/youth cortisol at Time 1 and Time 2 would be consistent with attunement. Next, in our *second analytic approach*, similar to other investigations of attunement (Hibel et al., 2015), we evaluated the interaction effect between generation (parent or youth) and time on cortisol using the MIXED procedure in SPSS to run a multilevel model to account for the non-independence of parent and adolescent, to determine whether parent and adolescent cortisol levels differed from each other prior to and after the task and whether there was an interaction. To be consistent with attunement, we would not expect an interaction between generation (parent or youth) and time. In this situation, non-significant results provide support for attunement. In our *third analytic approach*, using a regression model, we hypothesized that parent cortisol at Time 2 would predict youth cortisol at Time 2 even after controlling for youth cortisol at Time 1 (and other control variables). Finally, in the *fourth analytic approach*, we utilized hierarchal regression, predicting cortisol *responses*, i.e., change from Time 1 to Time 2 to test whether the change in parents' cortisol reactivity predicted change in adolescent cortisol reactivity.

The second research goal focused on investigating whether genetic polymorphisms contribute to adrenocortical attunement and was investigated using two analytic approaches. Adding to the multilevel model tested in the second analytic approach of the first research question, we predicted that level of adrenocortical attunement would differ by genotype of the parent, such that parents with GG genotypes would show greater attunement. It also was hypothesized that in the difference score model (fourth analytic approach for the first research goal), the addition of the genotype variable would show that genotype would moderate the association between parents' cortisol response and adolescent cortisol response. Specifically, we expected this association to be stronger among parents with the GG alleles.

## Results

### Research Goal #1:

For the first research goal, we examined whether adrenocortical attunement occurred within a parent-adolescent disagreement task. Descriptive statistics are displayed in Table 1. As indicated in Table 2, the results of the first analytic approach demonstrated a strong association between parent cortisol at Time 1 and 2, $r = .75$, $p < .001$. Although statistically significant, the correlation between adolescent cortisol at Time 1 and 2 was much smaller in magnitude, $r = .47$, $p < .001$, than parent cortisol at Time 1 and 2 suggesting that adolescents had less consistency in cortisol between Time 1 and Time 2 than parents. Parent cortisol at Time 1 was correlated with adolescent cortisol at Time 1, $r = .26$, $p < .01$, and parent cortisol Time 2 was correlated with adolescent cortisol at Time 2, $r = .36$, $p < .001$. Thus, the

correlation between parent/adolescent cortisol levels was stronger in magnitude at Time 2, indicating increased adrenocortical attunement across the task.

Next, in our second analytic method, we ran a multilevel model to further investigate attunement effects. The first model included the effects of Time (1 and 2) and Generation (adolescent and parent) in a multilevel model, controlling for adolescent ethnicity (dummy-coded categorical variable), time of day (continuous), and income-to-needs ratio (continuous) to predict cortisol levels. The main effect of time was significant, $F(1, 337.54) = 50.86$, $p < .001$, indicating a statistically significant decrease in cortisol over time. The main effect of generation, reflecting differences between parents and adolescents on levels of cortisol was marginally significant, $F(1, 340.55) = 3.68$, $p = .06$. Supporting the attunement hypothesis, the interaction between time and generation was not statistically significant, $F(1, 337.55) = 0.09$, $p = .76$, suggesting that the effect of time does not vary based on generation within the dyad. More precisely, based on these results we cannot conclude that the effect of generation varies based on time among parents and adolescents and thus these results are consistent with attunement.

In our third analytic approach to investigate attunement further, we examined the effects of parent cortisol at Time 2 predicting youth cortisol at Time 2 controlling for adolescent ethnicity, income-to-needs ratio, time of day, and youth's cortisol levels at Time 1. First, we ran the analysis including covariates only. As shown in the first portion of Table 3 (Step 1), the set of covariates account for 19.9% of the variation in adolescent cortisol at Time 2, $R^2 = .199$, $F(6, 105) = 4.35$, $p < .01$. Next, we controlled for adolescent cortisol at Time 1 (Table 3, Step 2). Not surprisingly, this adolescent cortisol at Time 1 was a statistically significant increase in variation accounted for in adolescent cortisol at Time 2 over and above the set of covariates, $R^2_{Change} = .122$, $F(1, 104) = 18.63$, $p = < .001$. Finally, we added parent cortisol at Time 2 in the model (Table 2, Step 3). Consistent with attunement, there was a statistically significant increase in the proportion of variation accounted for in adolescent cortisol at Time 2 by the addition of parent cortisol at time 2, $R^2_{Change} = .062$, $F(1, 103) = 10.40$, $p = < .01$. Thus, after controlling for the covariates and adolescent cortisol at Time 1, parent cortisol at Time 2 was predictive of adolescent cortisol at Time 2; parent cortisol at time 2 accounted for 6.2% of the variation in adolescent cortisol of Time 2 after controlling for the covariates and adolescent cortisol at Time 1.

To address the research question further, we investigated adrenocortical attunement using a change score approach (fourth analytic method). First, change scores, reflecting the overall cortisol response to the task, were created by subtracting Time 1 raw cortisol levels from Time 2 raw cortisol levels for both parent and adolescent; adolescent cortisol change score was used as the outcome in the model. Adolescent ethnicity, income-to-needs ratio, and time of day were used as covariates in all analyses. As shown in the first section of Table 2 (Step 1), only time of day was statistically significant ($\beta = .27$, $p < .01$) and the model accounted for only 10.8% of the variation in change scores, $R^2 = .108$, $F(6, 102) = 20.57$, $p = .07$. Parent cortisol change (Step 2) was then added to the model, and the overall model was significant, $F(7, 101) = 2.48$, $p = .02$, $R^2 = .15$, suggesting that the addition of parent cortisol change scores increased the proportion of variation estimated by 3.9%, $\beta = -0.28$, $p = .03$; time of day continued to be a statistically significant predictor, ß = .32, $p < .01$. These

results further support our expectations for the first research goal; specifically, the change in parents' cortisol from pre-task to post-task predicted adolescent cortisol change from pre-task to post-task. This indicates that parent cortisol changes significantly predicted the changes in adolescent cortisol over the task; however, these relationships will be further explored among different parent allele characters in the next research goal.

### Research Goal #2:

For the second research goal, we examined whether genetic polymorphisms contributed to adrenocortical attunement and adolescent stress response to the task. We tested this using two analytic approaches. First, genotype (GG vs A-allele carriers) was added to the multilevel model described in the previous section, the second analytic approach for the first research goal. The main effect of Genotype on cortisol was not statistically significant, $F(1, 423.57) = 1.08$, $p = .299$. The interaction between time, generation, and genotype also was not statistically significant, $F(1, 326.36) = 0.08$, $p = .78$; nor was the interaction between time and genotype, $F(1, 326.34) = .11$, $p = .736$, or generation and genotype, $F(1, 413.93) = .022$, $p = .88$. Contrary to our hypothesis, the level of cortisol attunement was not moderated by parent genotype. Thus, we cannot conclude that parents with GG genotypes show more attunement.

To further investigate whether parent genotype moderates attunement, we added parent genotype to analytic approach four from research goal 1. We assessed whether parent cortisol change, parent genotype (GG vs A-allele carriers), and the interaction between the change in cortisol and genotype predicted adolescent cortisol change controlling for ethnicity, income to needs ratio, and time of day. As shown in Table 4, Step 3, the inclusion of Parent genotype only accounted for an additional 0.2% proportion of variation in adolescent cortisol change, $F(1, 100) = .076$, $p = .68$ over and above the control variables and parent change in cortisol. In Step 4, we added the interaction between parent cortisol change and parent genotype. The overall model was significant, $F(9, 108) = 1.96$, $p = .05$, $R^2 = .15$. As shown in Table 2, Step 4, the interaction between parent cortisol change and parent genotype, however, was not statistically significant, $\beta = .08$, $p = .57$. Based on these results, we cannot conclude that genetic polymorphisms contribute to adrenocortical attunement.

## Discussion

The purpose of the current investigation was to examine the social (via a parent-youth disagreement task) and genetic contributors to adrenocortical attunement between parents and adolescent girls from predominantly low-income, single parent, and ethnic minority families. Specifically, we explored whether parents and adolescents from ethnically and economically diverse backgrounds show adrenocortical attunement during a disagreement discussion and whether OXTR polymorphisms were linked to parent-adolescent physiological attunement. To address these research goals, we assessed parent and adolescent cortisol levels before and after a parent-adolescent disagreement discussion task. Parents and adolescents showed coordination in both absolute cortisol levels and cortisol

reactivity to the discussion. Oxytocin receptor polymorphisms did not significantly impact the level of physiological attunement between parents and adolescents.

## Adrenocortical Attunement

The first research goal of the current investigation was to investigate adrenocortical attunement within the context of a parent-adolescent disagreement task in low-income adolescent girls and parents (predominantly biological mothers). This is a critical research goal given that we currently lack understanding of whether and how physiological coordination occurs between adolescent daughters and their parents living in adverse conditions with a multitude of daily stressors, and the relatively sparse research documenting these developmental changes in these environments (Davis et al., 2018). Examining parent-adolescent attunement is especially critical due to the number of physiological changes occurring during adolescence (Steinberg & Morris, 2001). The results indicated that parent and adolescent cortisol levels were attuned and that changes in parent cortisol levels across the task predicted adolescent cortisol changes. The findings suggest that parental social interaction factors, as part of the contextual environment in which the adolescent develops, can predict the stress response system of the adolescent in an acute, disagreement-driven task. In and of itself, the cortisol levels of the parent can influence or predict the stress responsiveness of adolescents to acute disagreement tasks. These results are consistent with other investigations of mother-adolescent biorhythms which have found adrenocortical attunement to be predictive of positive relationship outcomes (Papp et al., 2009). It is possible that adolescence is a critical developmental period during which sensitivity to the behavioral and emotional cues of the parent-adolescent dyad may be involved in regulating stress response and emotions. This type of regulation may be especially critical among adolescent girls from backgrounds with fewer resources to allow them to navigate the challenges of this developmental stage.

This study contributes to the nuanced understanding of the parent-adolescent biorhythm in potentially important ways. First, there was evidence that parents' cortisol response profile contributed to dyadic attunement during disagreement discussions with their adolescent daughters. The notion that parent behaviors may influence adolescent cortisol responses in the current study is further supported by the time-dependent effects found for parent and adolescent cortisol levels, with parent cortisol change predicting adolescent cortisol change levels. This is not to say that adolescents are passive in their own development and are not contributing in important ways to these interactions; however, the current data suggest that behaviors and responses may be initially parent-driven, especially in disagreement-related situations, as was mirrored in the current study's task (see Ha et al., 2016 for a discussion).

Stress system coordination with close others may be particularly adaptive for adolescent girls in psychosocial contexts characterized by unpredictability of resources and social behavior (e.g., interpersonal or neighborhood violence). Some of the core functions of the stress response system are to translate and categorize information about the psychosocial context, to mediate openness to environmental inputs and to regulate one's physiology and behavior to enable optimal responding to psychosocial challenges (Del Giudice et al. 2011). Adrenocortical attunement to a caregiver may be one mechanism that allows for the

calibration of the stress response to these disagreement experiences. Physiological and behavioral attunement allows for the exchange of information between children and their caregivers across development that aids in learning across multiple domains (Byrd-Craven & Clauss, 2017). For female adolescents from predominately low-income, single parent, ethnic minority families, coordinating their stress responses to that of their caregivers may be particularly critical, as it would better prepare them to meet and respond to challenges occurring within and outside of their family environment.

## Genetic Contributions

For the next research goal, we investigated whether genetic polymorphisms contributed to adrenocortical attunement and adolescent stress response to the task both in terms of main effects and moderating effects. These analyses were critical as they can illuminate the role of genetic factors in shaping dyadic coordination in the stress response systems. In particular, OXTR (rs53576) showed no systematic influence over the stress system responsivity and intra-individual coordination to a disagreement discussion task over and above other factors. Based on previous research suggesting this single nucleotide polymorphism (SNP) may impact parent-child interactions in addition to stress response (Chen et al., 2011; Feldman et al., 2012), we predicted a significant gene-by-context interaction (G X C) effect for adrenocortical attunement following the disagreement discussion. We found, however, that parent and adolescent genotype did not influence attunement, suggesting that while OXTR may shape early parent-child socialization, it may not play an active role among adolescent girls from low-income families.

These results are consistent with a number of recent investigations of oxytocin receptor polymorphisms. A recent meta-analysis has revealed that the two commonly studied SNPs, rs53576, studied here, and rs2254298, failed to account for social behaviors across several domains (Bakermans-Kranenburg & van IJzendoorn, 2015). OXTR rs53576 has been found to influence stress responses to social rejection, but these effects were nuanced and dependent on several other traits as well (Auer, Byrd-Craven, Grant, & Granger, 2015). Further, it is possible that other biosocial mechanisms may be more important in the stress response among parent-child dyads (Li et al., 2015).

## Limitations and Future Directions

One methodological limitation was the assessment of cortisol at only two time points, as an additional sample would have allowed for the assessment of the recovery period from a stressor (i.e., the disagreement discussion task), which would give a greater understanding of how these individuals physiologically recover from a parent-adolescent disagreement. Additionally, as mentioned above, a smaller sample size, such that AA-allele carriers were underrepresented, caused analyses to collapse into two categories instead of three potential categories. Sample size and composition may be other factors related to the lack of significant genotype findings. SNP effects are, by definition, expected to be relatively small and require large sample sizes. With only just over 100 dyads, it is likely that our sample was under-powered to detect these relatively small effects. Relatedly, though our sample was more ethnically diverse than most (approximately half of the sample was African American), allele diversity was limited. With only one adolescent and one parent homozygous for the A

allele, we primarily compared AG to GG. While there is empirical support for collapsing A allele carriers into one category (Norman et al., 2011; Rodrigues et al., 2009), this may have masked any small effects. Additionally, the relative paucity of previous literature on low-income, minority adolescent females limits the interpretation of the results, such that conclusions in the context of the larger developmental literature is difficult when the majority of research is conducted on European American, middle class families. Finally, future research would benefit from samples with both adolescent boys and girls from low-income families.

However, the current study's examination of multiple aspects and their effects on parent-child biological attunement during a disagreement task allows a multifaceted, contextually rich look into myriad developmental trajectories and outcomes of those adolescents. Future longitudinal research can further inform contributing factors in the adolescents' environment (e.g., father involvement, interpersonal trauma) to context-specific tasks (e.g., a parent-child disagreement task) and changes in those interpersonal, acute interactions longitudinally. These underlying biological mechanisms are important considerations in the adaptive calibration of the stress response system over development (Del Giudice et al., 2011), and should be considered and studied over time, including younger ages in order to predict outcomes in across the adolescent developmental period.

In conclusion, the current study presents a snapshot into parent-adolescent social dynamics that influence how these dynamics are translated into biological and psychological outcomes for both parents and their adolescent daughters. Like interactional synchrony (Criss, Ingoldsby, & Shaw, 2003), cortisol attunement in the context of the parent-daughter dyad may have developed to provide a means for modulating the stress response during a critical developmental transition (Steinberg & Morris, 2001). Further study is needed to determine how these influences accumulate over the course of development, particularly in populations in which less is known about potential buffers to chronic stress.

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Data Availability Statement:

The data that support the findings of this study are available on request from the corresponding author (JBC). The data are not publicly available due to containing information that could compromise the privacy of research participants.

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**Table 1.**

Means and standard deviations of key study variables

| Variables | *N* | *M* | *SD* |
|---|---|---|---|
| Youth Time 1 (pre-task) Cortisol | 117 | 0.18 | 0.32 |
| Youth Time 2 (post-task) Cortisol | 118 | 0.14 | 0.11 |
| Parent Time 1 (pre-task) Cortisol | 113 | 0.24 | 0.41 |
| Parent Time 2 (post-task) Cortisol | 115 | 0.18 | 0.38 |
| Youth Cortisol Change | 117 | −0.05 | 0.16 |
| Parent Cortisol Change | 113 | −0.06 | 0.14 |
| Income-to-needs ratio | 116 | 1.61 | 2.00 |
| | ***N*** | **%** | |
| Youth OXTR (% A allele) | 116 | 38.8% | |
| Parent OXTR (% A allele) | 116 | 44.8% | |
| Adolescent Ethnicity | | | |
| African-American | 58 | 49.2% | |
| Caucasian | 28 | 23.7% | |
| Hispanic | 4 | 3.4% | |
| Native American | 17 | 14.4% | |
| Other | 11 | 9.3% | |

**Table 2.**

Correlations among Log Cortisol Levels.

| *Variable* | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1. Parent Log Cortisol Time 1 | -- | | | |
| 2. Child Log Cortisol Time 1 | .26** | -- | | |
| 3. Parent Log Cortisol Time 2 | .75** | .21* | -- | |
| 4. Child Log Cortisol Time 2 | .45** | .47** | .36** | -- |

* $p < .05$,

** $p < .001$

**Table 3.**

Results from Regression Analyses Predicting Adolescent Log Cortisol at Time 2

| Step | Variable | $\Delta R^2$ | *Std.* $\beta$ | *t* | *p* |
|---|---|---|---|---|---|
| 1 | Control Variables | .199 | | | <. 01 |
| | Youth Ethnicity[a] | | | | |
| | African American | | 0.28 | 2.55 | .01 |
| | Hispanic | | 0.12 | 1.31 | .20 |
| | Native American | | 0.26 | 2.56 | .01 |
| | Other | | 0.04 | 0.39 | .70 |
| | Income-to-Needs Ratio | | 0.19 | 2.08 | .04 |
| | Time of Day | | −0.33 | −3.69 | <.001 |
| 2 | Adolescent Log Cortisol (Time 1) | .122 | 0.40 | 4.32 | <.001 |
| 3 | Parent Log Cortisol (Time 2) | .062 | 0.26 | 3.23 | <.01 |
| | Overall $R^2$ | .383 | | | <.001 |

*Note:* Standardized regression coefficients. Each step incorporates all predictors from the previous step.

[a] = Dummy coding was used to incorporate ethnicity in the model with European Americans used as the reference group.

**Table 4.**

Results from Regression Analyses Predicting Adolescent Cortisol Changes

| Step | Variable | $\Delta R^2$ | *Std.* $\beta$ | *t* | *p* |
|---|---|---|---|---|---|
| 1 | Control Variables | .108 | | | .07 |
| | Youth Ethnicity[a] | | | | |
| | African American | | 0.00 | 0.99 | .99 |
| | Hispanic | | −0.04 | 0.65 | .65 |
| | Native American | | 0.07 | 0.67 | .50 |
| | Other | | 0.00 | −0.05 | .96 |
| | Income-to-Needs Ratio | | 0.11 | 1.13 | .26 |
| | Time of Day | | 0.27 | 2.84 | <.01 |
| 2 | Parent Cortisol Change | .039 | −0.28 | −2.15 | .03 |
| 3 | Parent Genotype[b] | .002 | 0.04 | 0.42 | .68 |
| 4 | Parent Cortisol Change X Genotype | .003 | 0.08 | 0.57 | .57 |
| | Overall $R^2$ | .151 | | | .05 |

*Note:* Standardized regression coefficients. Each step incorporates all predictors from the previous step.

[a]Dummy coding was used to incorporate ethnicity in the model with European Americans used as the reference group.

[b]1 = AA/AG and 2 = GG;